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Research on Governance of Potential Safety Hazard in Da'an Mine Goaf

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Abstract

In order to eliminate the potential safety hazard of lower part mining caused by mine goaf and ensure the safety of workers and equipments, treatment measures on mine goaf should be carried out as soon as possible. Through comparison between programs and numerical simulation, comprehensive treatment solution including subarea blasting caving and mine goaf closing is chosen, meanwhile recycling parts of resources is carried, which may achieve safe, economic and high effective purpose and also lay the foundation for enterprise in continued production. The treatment mode of potential safety hazard in Da'an mine goaf can provide reference for similar mine goaf.

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*Keywords :*Mine goaf, potential safety hazard, subarea blasting caving

1. Introduction

The mine goaf which created from producing mine may have a direct or indirect threat to mine safety production. On the one hand, workers and equipments may fall into the mine goaf and get hurt. On the other hand is that as a result of abundant mine goaves existing, the mining conditions become worse, causing deformation of ore pillar, difficulty in the maintenance of nearby stope and roadway, a large area

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undershaft caving, rock movement and surface subsidence and other disasters, even more serious is that the high-speed airflow generated in sudden collapse of the mine goaf and shock waves will cause casualties and equipment damage, which give a serious threat to mine safety production, and lead to environmental degradation, a serious waste of mineral resources[1].

For various reasons, there are lots of untreated mine goaves in many metal and nonmetal mines of our nation, especially since the 1980s, China's mining laws and orders are confused, a variety of illegal, unauthorized exploiting and digging in a number of mines have left a large number of unknown mine goaves, resulting in deterioration of mining conditions, which not only make serious impact on mine production and safety, but also lead a great destruction and waste of valuable mineral resources underground[2].

As the various forms of disasters such as sloughing, roof fall, water gushing-out, shock bump, ground subsidence, landslides, mud-rock flow, surface vegetation destruction which induced by mine goaf are increasing, especially the heavy accidents have an enlarging trend. For instance, 7.17 serious water gushing-out in Nandan of Guangxi province, 11.6 serious gypsum mine collapse accidents in Shangwang area of Xingtai city, and so on, which are all typical security incidents caused by mine goaf. [3]

Da'an mine used to mining by shallow-hole shrinkage stoping, the protective layer pillars are left between mine goaves, thickness of pillar ranging from 2.5 ~ 10m, the height of mine goaf from 3.5 ~ 10m, according to estimates, the amount of mine goaf reaches to 60,000 m3, as a result of the high-strength surrounding rocks and good wholeness of mine goaf, the stability of mine goaf is still fine. However, with the increasing exposure time and the influence on bottom mining that could damage the pillars. Once large area of collapse occurs, the vibration and shock will constitute a serious threat to deep mining, which may be a problem that can't be ignored to mining safety and production.

Therefore, how to cope with the existing mine goaf and eliminate the security potential risks, at the same time recycle a large number of valuable resources become extremely big problems waiting to solve in Da' an mine.

2. Basic overview of Da'an mine goaf

The ore body of Da'an is sharp-inclined which is divided into several stages to exploit from top to bottom, using adit combined with ramp exploiting way in the upside and adit open stope mining method; shaft exploiting way and shallow-hole shrinkage stoping method have been used in the deep part. So far, adit PD1-PD8 have been mined out above the horizon, only in several adits still have sporadic remaining pillars waiting to be recycled; below the adit PD8 cutting, mining and stoping are still proceeding. [4]

Above PD8 in mine goaf have an inclined direction along the trend of lode, keeping pillars only between parts of mine goaves, similar to the slab-like building. As stoping is not standardized, in addition the enterprise prefer the rich ore to the poor, the remaining protective layer pillars are very irregular, thickness of pillar from 2.5 ~ 10m. The height of layered mine goaf from 3.5 ~ 10m, according to estimates in mine goaf, the total amount reached 60,000 m3,the overstocking mineral resources of pillar amounted to 743,000 tons. Basic overview of Da' an ore body in Figure 1.

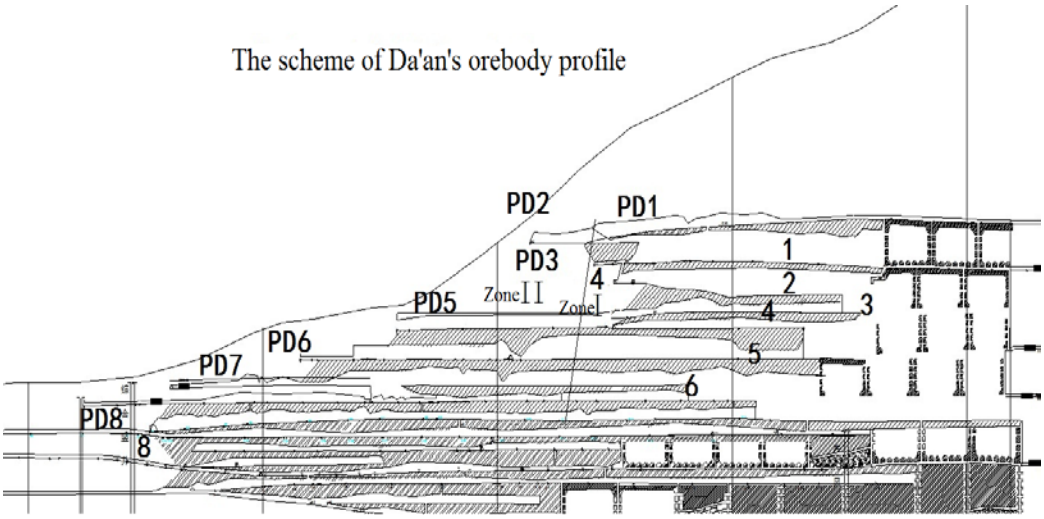

Fig. 1. Profile figure of Da'an ore body

3. Governance methods of potential safety hazards in Mine goaf

3.1. The selection of methods

3.1.1. General treatment methods of mine goaf

There are mainly three treatment methods of mine goaf: surrounding rocks caving, mine goaf filling and mine goaf closing.

The feature of surrounding rocks caving in treatment of mine goaf is using middle-deep hole, deep hole or blasting chamber method and blasting lots of surrounding rocks to form a buffering protective cushion, meanwhile filling in the mine goaf, thus preventing that the rocks of mine goaf suddenly fall down and cause harm. Using surrounding rocks caving to treat mine goaf could eliminate open-stope, alleviate stress that over-concentration and avoid activities of ground pressure in large-scale, and the treatment process is relatively simple. For the existence of a large number of top-pillars in mine goaf, some of the resources can be recycled. Therefore, this method is widely used in domestic mines.

Filling treatment of mine goaf. It can change the state of rock stress, controlling the strain of surrounding rocks and limits of displacement in the allowable range, improving its support capabilities and the regional controlling effects of ground pressure, but the cost of filling treatment is higher.

Closing treatment of mine goaf. This method cannot improve the situation of ground pressure, but it can isolate the danger zone from the production area, the cost is lower and the timeliness is worse. This method is suitable for the mine goaf which has steady ore rocks and smaller scale[5].

3.1.2. Selection of treatment method of Da'an mine goaf

The principle of treatment method of Da'an mine goaf is recycling the resources as much as possible when treating the mine goaf. According to the features of Da'an mine goaf and comparing the variety of programs and analyzing numerical simulations and calculations, the comprehensive treatment project known as caving - closing mine goaf method has been chosen. The main points of project are as follows:

（1）Using large-scale regional caving roof pillars, rib pillars and avoiding to adopt small-scale mining operations from causing disturbance to the remaining pillars and worsening the working

conditions of mine goaf; leave 10m pillar along the direction every 40m as permanent pillar that can support the mine goaf.

（2）Firstly caving down adit 8 roof pillar to form protective cushion which not less than15m, the centralized caving top pillar fell on the protective cushion, and then focus on a mine adit in PD8 and remove the ores, at the end there is still remaining protective cushion that not less than 15m.

（3）After the end of ores removal, leaving the protective cushion whose thickness is not less than 15m at the bottom of the mine goaf, and blocking all adit entrances that connecting to the surface.

（4）Leave 40m pillar in adit PD8 for ensuring safety of the lower part of post-mining after the treatment above on mine goaf.

3.2 Partition of caving

Because of the huge number of mine goaves, it is difficult caving all at one time considering both from difficulty of construction and workload. Therefore, caving by partition is the proper project we just need. Particular partition is that deviding adit PD2 as the boundary, set the west of it as area Ⅰ and east of it as area Ⅱ. First caving area Ⅰ, and then caving Ⅱ.

Before caving area Ⅰ and Ⅱ, first caving adit PD8 roof pillar to form protective cushion that is not less than 15m which take the ores from caving roof pillar in and protect the adit PD8 and the structural safety of the bottom when removing ores.

3.3 rock drilling

As a result of different thickness of the horizontal pillar and different height of mine goaves, thickness of roof pillar and height of mine goaf must be considered to determine the rock drilling methods.

The thickness of ore body range from 3.00m ~ 6.50m, the exposed area of mine goaf is small. Ore-rocks are hard and stable, so are the ore body and surrounding rocks in the mining tunnels. At the protection of the roof, use down-hole rock driller and drill downward hole in the existing stope.

For the height of mine goaf that is more than 7m or thickness of floor that is less than 3m of the top pillar, the rock drift should be arranged, and then drilled.

3.4 Demonstration of safety and stability

After the treatment on the mine goaf in the upper part, it is unknown whether there is some impacts on the lower part of mining safety. For this, numerical analysis is adopted. Analysis shows that: the stress mainly concentrates in the connection between the floor and up-down-plate surrounding rocks after processing the mine goaf, the up-down-plate surrounding rocks suffers extrusion and move toward the mine goaf after every roof pillars are caving. Design in the course of caving the roof pillars and processing the mine goaf is that in order to ensure mining safety of a level below adit PD8, keeping the 40m pillar in adit PD8 which can make sure of the mining safety of lower part.

4. Technical measures for safety

4.1 Reservation of buffer layer

The caving of large area in mine goaf is very serious accident in mines, with the harm reflect in many aspects: large-scale rocks collapse suddenly, the air which get rapid-compressed swarm out from the small section of roadway and form the impact waves which can blow down the equipments and destroy

the mining facilities, threatening the safety of the workers undershaft and even causing shut-down to mines when serious circumstances occur.

The high-pressure impact air wave created from caving bodies can not only cause impact destruction to the roadways that connect directly to the mine goaf but also pass through the cushion at the bottom of mine goaf and destroy the deep operation below the mine goaf. To avoid such damage, a certain thickness of the ore-cushion should be kept at the bottom of mine goaf to play a role in reducing the wind speed and the wind pressure.

Calculations shows: keeping 15m cushion when the impact airwaves which generated from caving shelters pass through the roadways and spread, the wave and its scope should be less than 550m from the mine goaf.

4.2 Pretending the mine quake caused by caving

The process itself of rocks falling in mine goaf is the process of energy releasing. When the falling rocks are moving in the air, before and after the falling rocks there are pressure difference generated, forcing a lot of air rapidly compressing and expanding which form an impact airwaves, releasing energy, applying work to the surrounding rocks of mine goaf and making rocks layer vibrating.

According to calculations, falling height is taken as 90m and falling capacity is taken as 43,200m3; the weight of rocks is 3.29t/m^3, the average area of the upper cushion is 4800m^2 and compressive strength of cushion rocks is calculated as 76.1MPa. The results show that thickness of the cushion reaches 15m, the load that lower part engineered body withstand is 9.72Mpa which is less than compressive strength of cushion rocks 76.1MPa. That the cushion can play a role in pretending the mine quake.

4.3 Closing measures

Closing all the tunnels of mine goaf that leading to the production area can effectively lower and reduce the influence on production face and workers which caused by impact wave. According to the distribution of the tunnels that connect with mine goaf, every key position of middle part should be blocked closely, isolating the mine goaf from the existing production system and pretending the destruction to the production system caused by impact wave when the roof of mine goaf is caving.

According to the distributional features of tunnels that near the mine goaf, close all eastern middle Lane (to prevent the impact on eastern shaft) , adit PD6,PD7(to prevent the impact on integrated shaft).

4.4 Safety Monitoring

The middle section of adit PD8 as the main level of ore removing and transporting is also return airway of nearby middle section stoping below adit PD8, the process of ores removal and next middle section stoping above adit PD8 should be kept stable. Therefore, it is necessary to start dynamic monitoring of activities of ground pressure on adit PD8 and other key locations, according to the monitoring results, adjusting the structure of parameters of stope, the mining order of ores body and the treatment of mine goaf and so on.

Monitoring methods. Recently there are mainly two monitoring methods of mine goaf: the one is artificially monitoring method, mainly measure the data of cracking and bosomy floor periodically, the cracking width and length of the extension of pillars, as well as the situation of sloughing and displacement, etc; the other is installing the rock sound automatic alarm device of the mine goaf, which can receive the rock sound launching situation inside the mine goaf, according to the size of the sound, making gradual alarm and gaining time for the evacuation of the workers and equipments.

5. Conclusions

Through comparison of several programs, calculation and analysis, the chosen comprehensive treatment program including subarea overall caving plus closing mine goaf is suitable and feasible, which meet the actual situation of Da'an stope. The program can not only ensure the safety and control potential safety hazards of mine goaf but also recycle lots of valuable resources.

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